Seismic base isolation: from the origins at today

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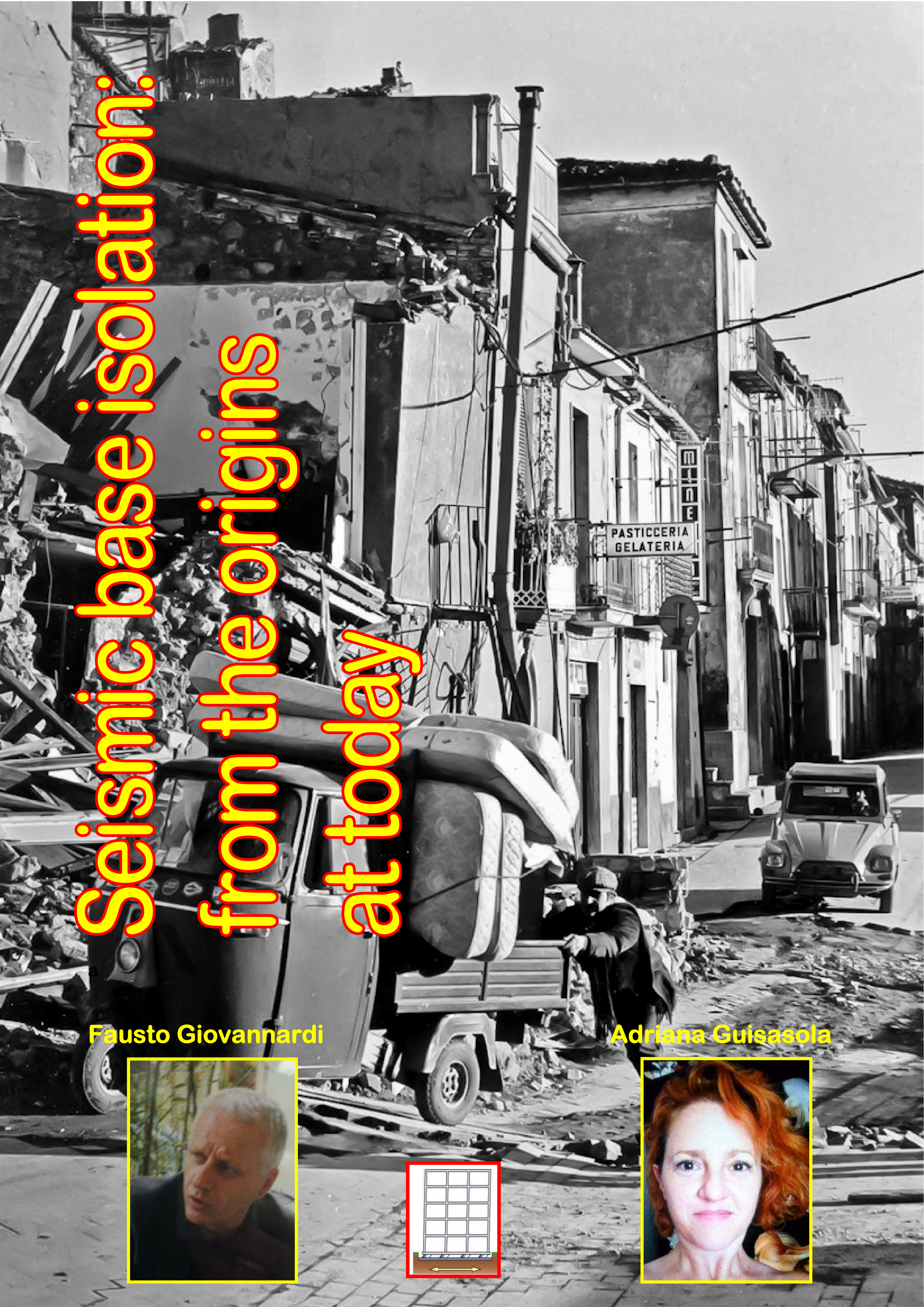

Introduction

The seismic isolation is a security technique that reduces the seismic action on buildings during earthquakes that has now proven its efficiency and economic competitiveness, compared to the usual mode of earthquake-resistant construction of bridges and buildings, and also in the protection of cultural heritage .
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The basic concept of seismic isolation is to reduce the effects of acceleration horizontal component of the ground, interposing structural elements in a low horizontal stiffness between the building and its foundation, decoupling, in fact, the motion of the structure from that of the ground. If the superstructure is rigid enough, is the first mode of vibration that passes and the displacements and deformations are concentrated only to the insulation system, while the higher modes, which produce the deflections in the structures, because orthogonal to the first, and to the movement of the ground, in this case, do not participate in the motion of the structure if not in an extremely limited manner, and therefore if the earthquake has a high energy content at high frequencies, this energy is not transmitted to the building.
This different way of thinking and design, recently appeared on the stage of modern earthquake engineering, it has ancient origins.

A history that has origins in antiquity

Historical research and archaeological campaigns, showed that ancient civilizations had in mind the need to build buildings that can withstand the earthquake. Thousands of years of tragedies had done school and the ancient builders knew the concepts of isolation and ductility.
The buildings of many ancient civilizations, especially the most important from the social point of view, have survived several earthquakes, even stronger, because their builders had realized the importance of including "elements" which had the function of dampening the effect by the earthquake.

In ancient Crete (2000 to 1200 BC) there were symmetrical buildings consist of single-celled bodies. The walls are made of stone blocks connected by wooden elements, which in addition to ensuring the connection between the blocks provide "plasticity" to all structural and compensate the "fragility" of the stone. The buildings are placed on a layer of sand and loose gravel, which besides serving for the leveling of uneven ground, exert a filtering action against vibrations in the ground during the earthquake.
Connections between masonry and wood similar foundation have also been found to Panticapaeum, in ancient construction (400 BC).

According to the great American archaeologist Carl Blegen, in the construction of the great walls of Troy (1500 BC), under the foundations of the great wall it was deliberately left a layer of compacted earth (hard-packed) between the foundation plan and the base rock. Highlighting the similarity with the used technique, over a thousand years later (III century BC.), in the temple of Athena at Ilion whose foundations rest on a thick layer of sand, as well as the Doric temples of Paestum (273 BC) .

In ancient Greece and Persia the technique had spread to interpose between the ground and the foundations of the temples, a few layers of material to make "translate" the building to the ground during an earthquake. In some cases below

the column, there was a layer of lead. Also the same base hewn stone and not walled contributes to isolation by the earthquake.
In some cases, the walls built on a strong foundation at the base of which put ceramic layers and clay. The ceramic protecting the clay layer of moisture and dehydration, maintaining over time the plastic properties. The high plasticity of clay muffled vibration of the ground during an earthquake.

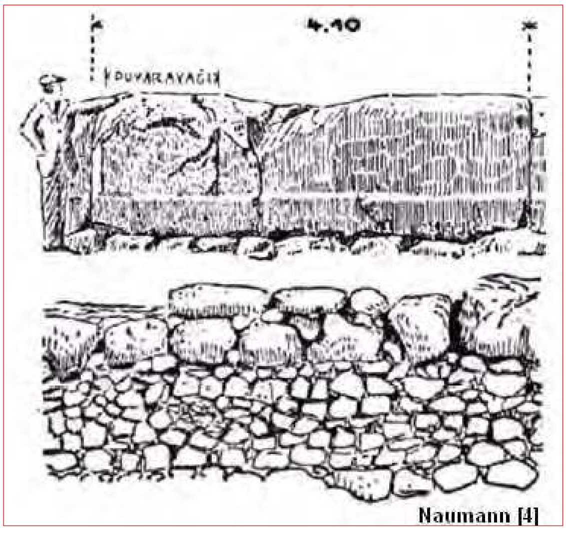
Another example of seismic isolation is represented by the construction technique that it planned to build between the foundation and the masonry a horizontal joint made from thin mortar of silt, sand. When the seismic action exceeds certain values, lean mortar is destroyed and the building slips. Good results are found even when the foundation is composed of several layers of polished stone, with no mortar or binding material, as in the tomb of Cyrus the Great in Pasargadae, southeast Iran, built in 550 BC
Similar considerations can be made for the Parthenon, to which are added considerations on the metal connections between the constituent elements of the tall columns.

The Temple of Artemis at Ephesus (VI sec. B.C.)
One of the seven wonders of the world

"Graecae magnificentiae vera admiratio exstat templum Ephesiae Dianae CXX annis factum a tota Asia. In solo id palustri fecere, ne terrae motus sentiret aut hiatus timeret, rursus ne in lubrico atque instabili fundamenta tantae molis locarentur, calcatis ea substravere carbonicus, dein velleribus lanae." (n.h., 36,95)

"An embodiment of the Greek grandeur worthy of a true marvel is the temple of Diana at Ephesus that still exists, which undertook the construction across the Asia for 120 years. It erected in a marshy area, because it does not suffer earthquakes or fear soil cracks; on the other hand, because they did not want the foundation to such a majestic building were above on a soil so slippery and unstable, was placed under them a layer of coal fragments and another of wool fleeces. "
Plinio il Vecchio, *Naturalis Historia, Libro XXXVI*
Pliny the Elder

Recent archaeological studies have shown a very common technique in areas subject to earthquakes of ancient Persia and called Orthostat stone layer. The layer of soil below the buildings was prepared in this manner: a first flat stones of small size layer, then some layers with stones of larger dimensions that become the foundation.
The stones are combined with dry, without any mortar or binder material, the mechanism is such that no sliding occurs in reality; or more precisely, there is a small flow and the return to their original position, after the earthquake. In fact studies have shown that the structures still standing after so many centuries, are in the same starting position and this would not be possible if there had been sliding, because even if you were moved by 1 cm every major earthquake, should now



Orthostat stone layer

be shifted to some tens of centimeters. One reason for this good behavior, could be linked to the vertical component of the earthquake, which is never taken seriously.

In the palace of Toprak-Kala in Uzbekistan (300 BC) it is the entire lower part of the walls to be more flexible, for the presence of mortar with clay mixed with cement. Even for contemporary Colossus of Rhodes, the legend has it that rested upon layer of goat skins, evidently insufficient to protect it from collapse in an earthquake.

The Colosseum in Rome (A.D. 70) the bottom layer rests on a layer of small stones superimposed on a medium-sized stones and then the layer of clay.

This technique has also been followed in more recent times. You have certain references an application in Kyoto, the Sanjusangendo (1160 A.D.), a Buddhist temple containing a famous building constructed to house a thousand statues.

In the Inca civilization it was known the importance of the geometric regularity, and some say that the walls in huge blocks of stone with very precise joints, rested on an insulating layer of sand and stones, which allowed the structure to settle without being damaged.

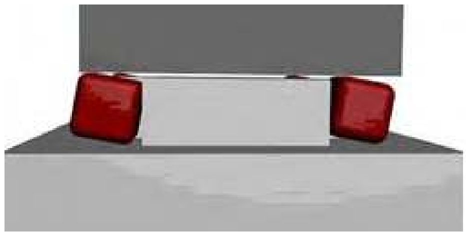
In the north of the current Iran, from 4000 BC, has developed a good practice of earthquake-resistant buildings. The ancient city of Masoleeh, composed by buildings of two or three-story adobe and mud walls, where the steepness of the terrain, the coverage of the buildings is the way of those overhanging; the structures are framed in braced wood at the corners and pat lightly adobe. At Lahijan foundations are composed of a double crossover layer of wood logs that roll on one another.

Important examples of isolation are located in the basement of the Kaaba at the center of Mecca, in the columns of casbha in Algiers and in the big Buddha at Kamadura (Japan

A special obelisk

The obelisk is usually an isolated, tall stone column, thin with a pyramid on top.
Hippodrome in Istanbul, Turkey, the **Dikilitash obelisk** has particular characteristics:
A block of stone of 18,69 m high, carved in Egypt in 1450 BC. Brought to Istanbul and erected in A.D. 379-395. Made on a marble Orthostat, rests on a 3x3x3 mt marble base through 4 cubes (50x50cm) Bronze seats in the corners.
Was calculated that may collapse in an earthquake with M> 7.6 and 5 km from the epicenter.

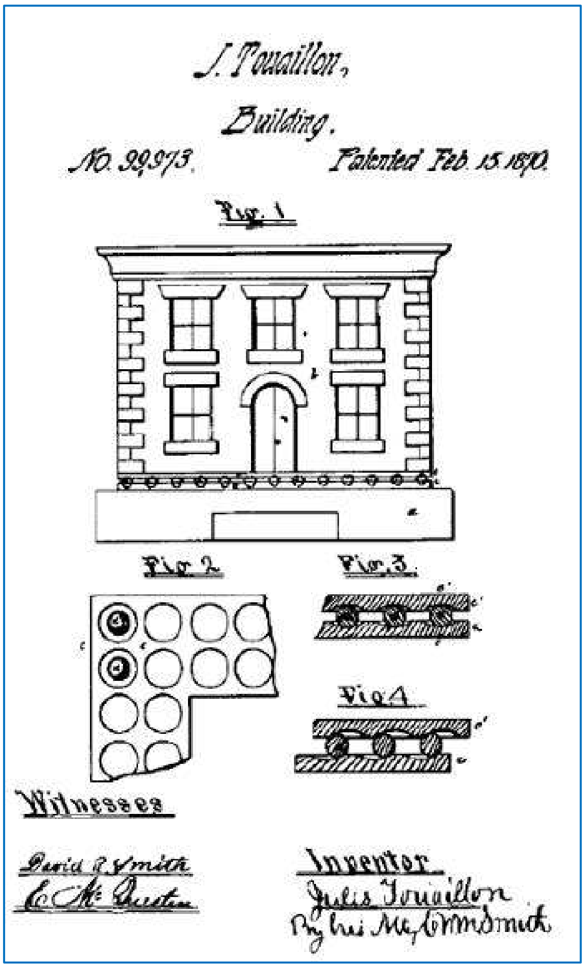


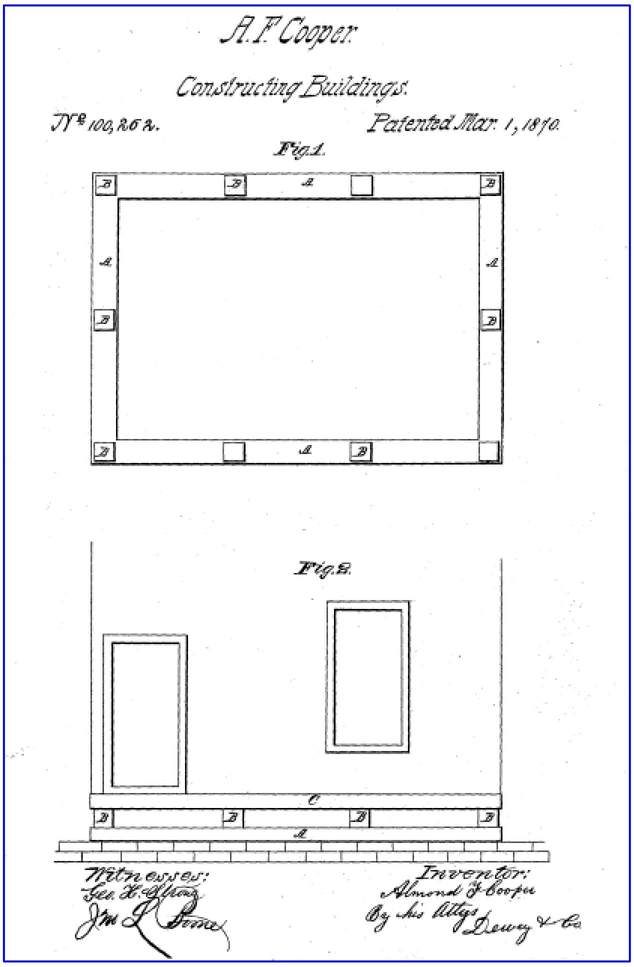


From the last century to the present day

The first document that certifies the idea of designing a building with a system that decouples the motion of the structure from the ground, dates back to February 15, 1870, by the Frenchman Jules Touaillon. His system involved the use of load-bearing balls placed between the base of the superstructure and the foundation. US Patent in San Francisco nr. 338240, 1870.

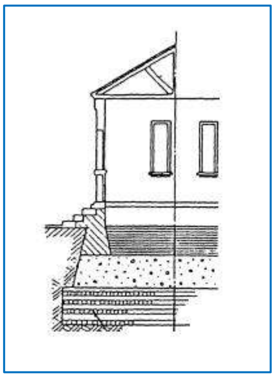
In the USA, a few days later, March 1, 1870, Almond F. Cooper has the patent no. 100,262 for "Improved foundation for Buildings" in which provides, under the walls of the building and above the foundation curb, the rubber isolators (India-rubber buffers).





A few years later, in 1885, **John Milne**, a British scientist among the inventors of the seismograph, who was professor of mining engineering at the Imperial College of Engineering in Tokyo from 1875 to 1895, builds his house in an isolated wood at the base, founded on poles on whose heads he entered the cast iron plates with edges, filled with little metal balls.

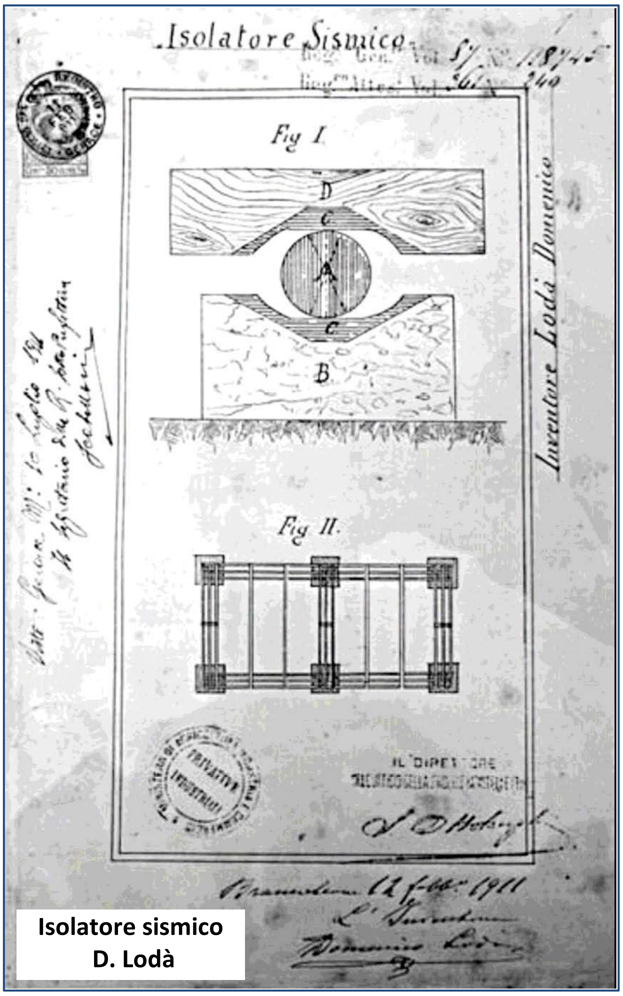
In December 1891, the no. 60 of the Journal of Architecture and Building Science, contains a **Kouzou Kawai** contribution illustrating the seismic isolation principle. The idea was similar to those carried out in ancient times and consisted in the insertion of alternate layers of concrete and wood logs beneath the structure.



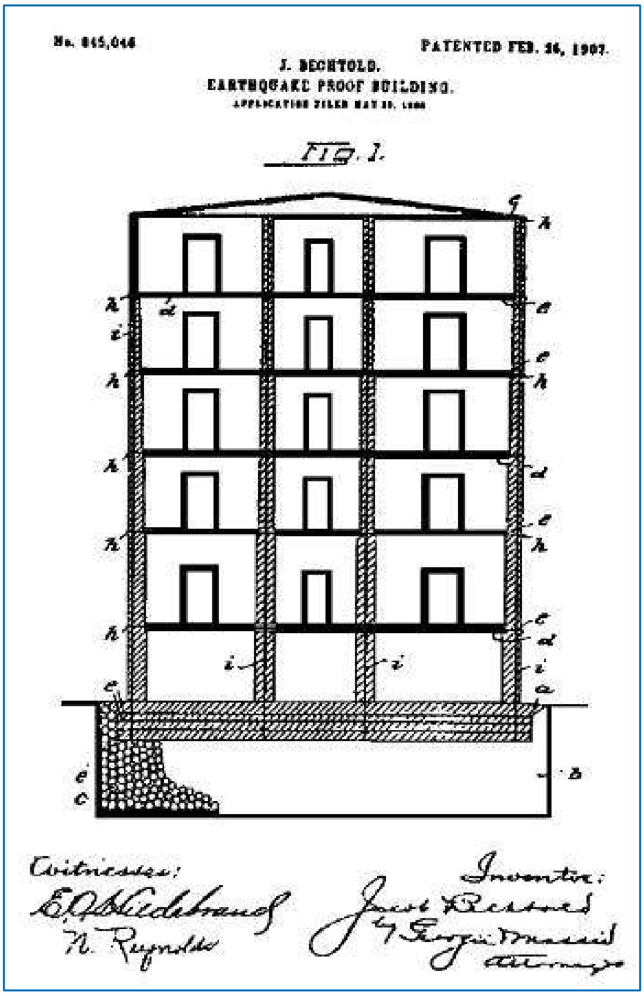
Kouzou Kawai

Of 16 February 1906, it is the patent **Jakob Bechtold**, which aims to create a box full of metal balls, that acted as "insulating cushion" for the structure.

Of 10 January 1909 is the patent n. 100,443 for a asismiche Foundations System, Eng. **Mario Viscardini** of Ferrobeton of Genoa presented Competition Messina, very similar to that patented in 1911, **Domenico Lodà**. Both provide a support system for buildings that prevented the transmission of the seismic movements and that anticipates the modern solutions of the inverted pendulum isolators[1].



Isolatore sismico
D. Lodà



[1] It is only in 2001, in fact, that Hyakuda et Alii experienced the system, known as Double Concave for Friction Pendulum – DCFP.

Something more detailed, with lots of special construction and wherein the connecting systems are also described between structure and networks, ingenious connections for gas and sewer networks, so as to prevent damage due to the large displacements, is located in a device seismic isolation which was filed in 1909 by J.A. Calantarients, a doctor of Scarborough, northern England. His proposal provides for the decoupling between the land and building, through the use of a layer of fine sand, mica or talc, which allows the building to slip during earthquakes transmitting to the construction reduced forces.

Johannes Avetician Calantarients explains his invention:

System of building and appurtenances to resists the action of earthquakes and like.

Since the system that I propose may seem like a novelty rather surprising, in the absence of a true experiment, on a building equipped with this system and then be able to prove their efficiency, I suggest a little experiment that illustrates the modus operandi, and which can be easily performed without leaving the breakfast table.

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Take two dinner plates and two cups egg. Spread a little of a sticky substance, such as honey or jam, on one of its cup bottom and then lay it firmly in the middle of one of the two plates. The jam is the mortar that binds the cup - the superstructure - the plate - the foundation of the building, typical of the modern way of building. Now take the dishes with both hands and move it as quickly as possible, from side to side, a few inches, as under the action of an earthquake. You will see the cup - the building - spill immediately. Now put the other cup in the middle of the other plate, where you put a little salt sprinkled over, to represent my building system with a free joint, without any binding material. Move it as before, and you will see the cup - the first building that collapsed, now simply slides from side to side, or so it seems, because it really is the pot - the foundation that runs from side to side, while the cup - the building, remains pretty much where it was.

The free coupling means that the earth is not in contact with the building, that to resist the shock does not therefore need to be reinforced, which means more expensive, more than necessary to bear its own inertia.

The degree of severity of an earthquake loses its meaning in a context like this, because the vibrations are faster and less likely to be transmitted to the superstructure. This can be well explained by an experiment with a glass of wine laid on a sheet laid on the floor, slippery, a table. As quickly as you pull away the sheet and less wine in the glass moves.

With regard to the cost of the material for the scroll area, I was able to calculate the price list of the nearby shop, and it is very little, especially when compared to the cost of the building.

If the plan is obtained with a rope made of asbestos (round or square section of an inch) along each side of the wall and the interior space filled with plaster of France or kaolin powder, for a 50 foot x 50 foot building (232 sq m), with 300 feet of the wall surface, wide one foot (30.48 cm), the cost is about £ 16 and £ 20 if the thickness is two feet.

Or if the scroll area is formed by a sheet of asbestos, of ¼ "thick, placed under the entire width of the wall, dusted with the powder on both its sides, the cost for the same building is about 12 £.

Or if you want to have a free coupling without lubricant layer, it can be expected to make the base of the superstructure of a type of stone capable of being pulverized by friction, so that over time may provide the right powder as a lubricant, when the dust placed there during the construction will end with the move.

So it describes the advantages of the buildings made of or protected by his system:

Among the many advantage claimed for this system, may be instanced the following:

1) First cost of structure designed and carried out in accordance with this system is appreciably less than present day building constructed to resist the action of earthquakes.

2) There are less calls for repair or maintenance of the fabric of the structures built upon this system.

3) the system amply provides for the continued durability of the structure, inasmuch as the action of the shocks however severs have comparatively non effect because the special shock absorbing zones give the necessary immunity.

4) There is freedom from disturbance and damage of glass, crockery, statues, and other portable goods, or works of art generally loosely placed in position.
5) There will be a great saving in annual payments for fire and life assurance, as less risks will be taken by offices, who it is thought will insure at lower rates for building or structures designed and built on this system.
6) There will be greater feeling of personal security against shocks by the occupants of buildings constructed or carried cut on this system, than by the practice of construction herotofore in use to resist earthquakes.
7) personal security against being buried in the ruins by sudden collapse of the building form earthquake, or burnt to death from subsequent fire.
8) No risk of fire, or interruption of gas or water supplies consequent on earthquakes, and generally a greater feeling of security all round when in buildings, liable to earthquakes, built in accordance with Dr. Calantarients system

Johannes Avetician Calantarients

J.A. Canaltarients born in 1838 in Armenia. After primary school in Istanbul, she moved to England, where he studied at the Theological College St. Aidan in Birkenhead and then at University College London and in Edinburgh, where he graduated in medicine.

Eclectic character, played as a doctor at the Hospital and Dispensary of Scarborough and inventor. 1869 is the invention of a portable barometer, certified by tests at the astronomical observatory at Kew. Wednesday, July 29, 1880, The Argus, Melbourne newspaper, reported the following news:

A new skating surface called " crystal ice" has been invented by Dr. Calantarients, of Scarborough. Considering that after all ice is merely a crystalline substance, and that there is no lack of substance a which are crystalline at ordinary temporatures, Dr. Calantarients experimented with a variety of salts, and after a time succeeded in making a mixture, consisting mainly of carbonate and sulphate of soda, which when laid as a floor by his plan can do skated on with ordinary ice-skates ; the resistance to the surface is just equal to that of ice ; it looks like ice, and, indeed, when it has been skated on and got "cut up" a little, the deception is quite astonishing. The surface can at any time to made smooth again by steaming with an apparatus for the purpose, and the floor itself when once laid will last for many years. The mixture of salts used contains about 60 per cent, of water of crystallisation, so that after all the floor consists chiefly of solidified water.

In 1895 he is vice president of the Anglo-Armenian Association based in London. The October 10, 1903 in The Lancet, published an article on his horse manure from the streets prevention [2].

In 1908, he is writing in The British Medical Journal article in relation to the widespread opposition to the vaccination. Report and draws the attention of a medical phenomenon, which believes it is resubmitting to the Hospital of Scarborought in 1871 again and found him when he was in service at the outbreak of an epidemic of smallpox. Of the numerous cases examined by him many concerned children vaccinated. Marveling at this began to interview the mothers, which confirmed the successful vaccination. He wanted to see the children's arm and saw that the vaccination had not attacked. Mothers in fact, contrary to compulsory vaccination, once executed ran home immediately and were washing the wound of vaccination, making it ineffective.

In 1909 the invention of the insulation system to the base for construction. (Italian Patent no. 101901 of 26 April 1909).
A letter he wrote the 8/27/1909 Count Fernand de Montessus de Ballore, director of the Seismological Servicio de Chile, to announce his invention of seismic isolation at the base, already submitted to Prof. Georg. Gerland director of the central office of the Strasbourg International Association of sismology, makes us think that J.A. Calantarientes was not an imaginative improvised inventor.

[2] The prevention of horse-dung in the streets.
The Lancet Volume 162, Issue 4180, 10 October 1903, Pages 1050–1051 J.A. Calantarients, M. U. Edin.

J.A. Calantarients, M.D.

27th Augt 1909.

8, Alma Square,
Scarbro'
England

Dear Sir

Under separate cover I send you the Description, with 2 sheets of illustrative drawings, & some explanatory notes, on a system I have devised for building constructions to resist the destructive action of earthquakes.

I have been induced to apply to you by the advice of Prof. Dr Gerland, Director of the Central Bureau of the International Seismological Association of Strassburg.

As a great authority on the subject of earthquakes, I beg you to do me the honour of examining my system & giving your opinion on it.

As you will see my main idea is that if the superstructure is separated from the foundation by a free & lubricated joint, the vibrating earth will have no solid rigid connexion with which to shake the superstructure, which, therefore, will only slides upon it.

As to any objection on the score of slide, since the amplitude of vibrations is very limited, ample room may be provided for it on the surface of the foundation.

I believe, therefore, very substantial buildings can be put up in Earthquake Countries on this principle, with perfect safety, since the degree of severity of an earthquake looses its significance through the existence of the lubricated free joint.

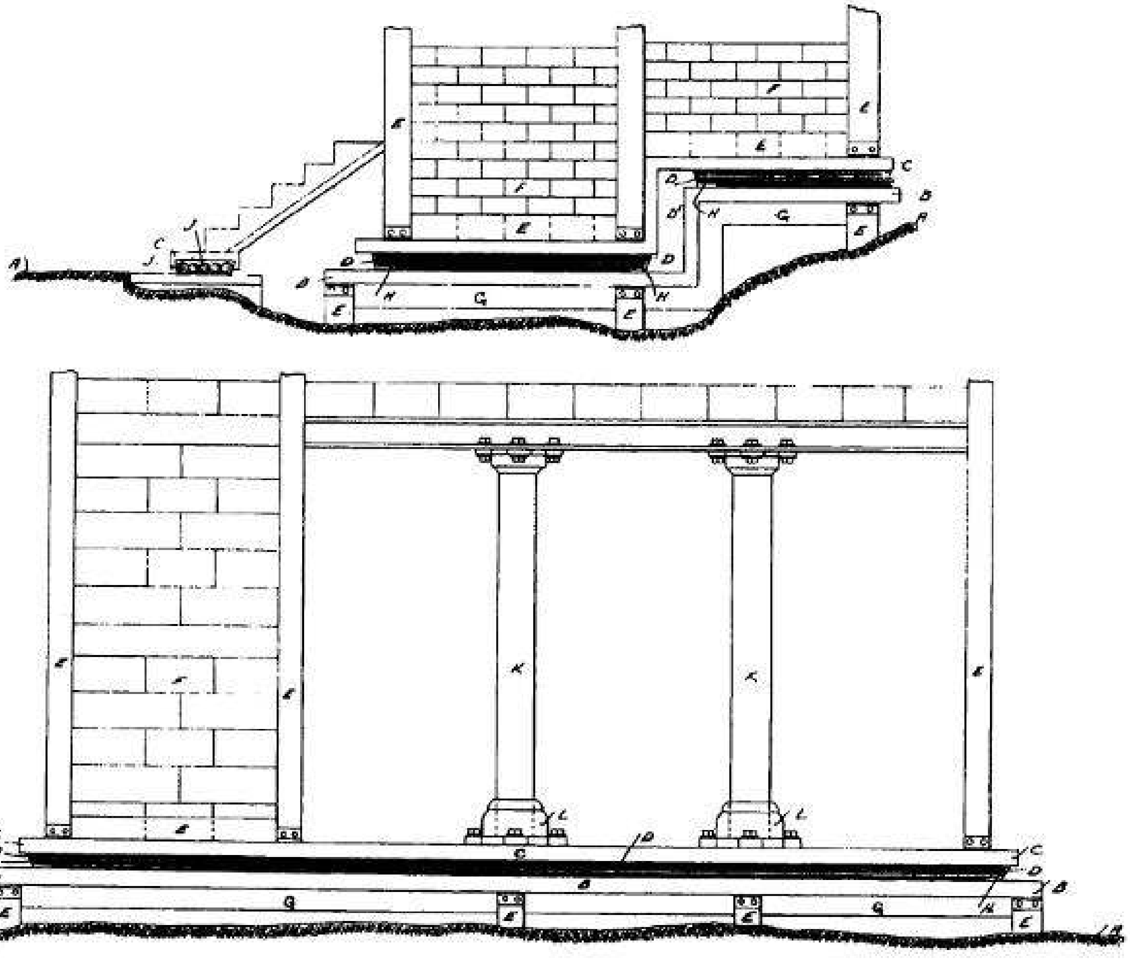
I made the experiment with balls many years before it was done in Japan, or at all events before any account of it appeared in the papers about 25 years ago.

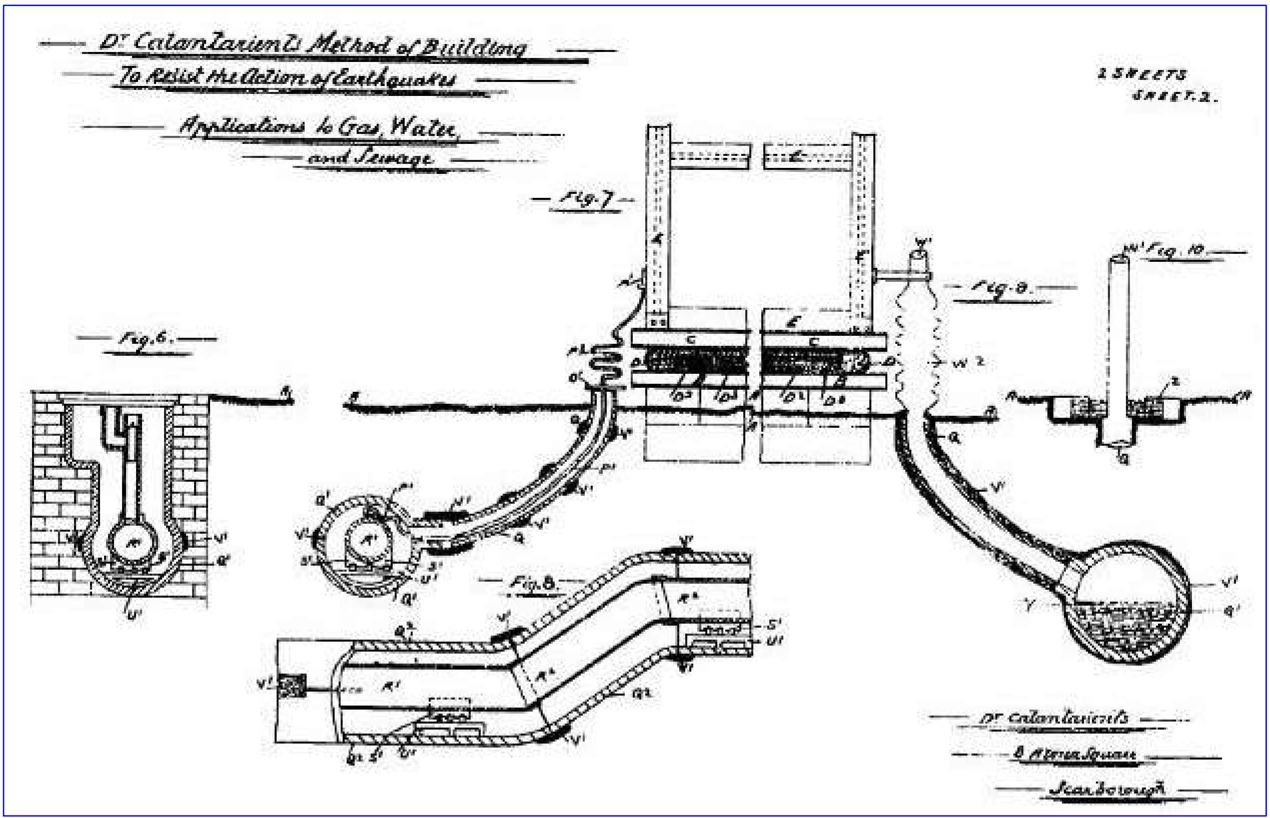
Yours faithfully

J. A. Calantarients M.D. &c

Conde Montessus de Ballore
Director del Servicio Sismologico de Chile
Avenida Republica 302
Santiago de Chile
Chile

DR. CALANTARIENTS METHOD OF BUILDING STRUCTURES AND APPURTENANCES
— TO RESIST THE ACTION OF EARTHQUAKES AND HIGH-WINDS —





Early last century, after strong earthquakes in San Francisco (1906) and Messina (1908) there were many proposals for earthquake-resistant construction technologies, including even that of Calantarients. Then also the earthquake in Tokyo (1923) stimulated the search for solutions to protect themselves from this terrible calamity.
Among the many proposals we note the one made by the Russian M.Visckordini, in 1925, with hinged pillars in the underground part of the building, which will find continuation in the future of his country[3].

The experience of the earthquake in Messina

After the earthquake of Messina-Reggio Calabria of 28/12/1908, with over 100,000 deaths and the destruction of the majority of brick houses, the whole world is shocked by the tragedy. A special commission was formed to suggest the modality of reconstruction, while many private initiatives were put in place. These include an international competition launched in the spring of 1909 by the Società Cooperativa Lombarda of Public Works and one in October, from the Tuscan College of Engineers and architects, both won by Arturo Danusso[4].

At the international competition in Milan, aimed at identifying the most suitable construction system for Reconstruction, confirmed the interest in the seismic isolation technique: 43 out of 214 competitors in fact present proposals to that effect.
The final report of the jury, rejecting proposals defined unserious or crazy, like the one in which the house was suspended from massive wire stretched between two bastions[5], He discarded the proposals of base isolation, to the difficulties of practical implementation and maintenance and durability, while it considered necessary for further testing proposals sandbars or debris to be interposed between the foundation and the base medium, and unanimously recognizes as deserving of approvals the proposals providing reinforced foundations and of such dimensions as

[3] see details on the Russian Federation
[4] See: Arturo Danusso e l’onere delle prove, in www.giovannardierontini.it
[5] Brev. 100231 di Bertelli Enrico Bibbiena (Ar)

to lower the center of gravity of the entire building, intimately linked to the superstructure, whether they were of reinforced concrete frames, that of wood or iron. Appreciation was also shown to those projects that had deepened the resistance issues related to the shape and distribution of the artifacts planimetric.
The competition was won by Arturo Danusso, who had filed a memorial on the dynamics of the structures in which introduces innovative concepts that will be the basis of earthquake engineering, and a project of reinforced concrete framed building based on a fixed foundation backward beams, connected to form a closed pattern.
Years later, remembering that time, write [6] : "*Coming out, I became curious a tiny cube-house model, fairy dressed in balconies and windows, and rested on the four corners of pegs spiral brass. A leaflet alongside noted candidly: "the news of the disaster has caused me a strong regional and national pain. I am a clockmaker, I practice springs, and I think they can make you service. Dates, please, tapping his finger: you will see the house swinging quietly and then stop without harm. The earthquake will have the same effect. Not premiatemi, but think and Provide*. "

The commission, in its conclusions, considers that there are two possible approaches for earthquake-resistant buildings: the first is those that plan to isolate the building from the ground through the interposition of a bed of sand beneath the foundations, or through 'use of rollers under the columns that allow the building to move horizontally. The second approach is the traditional fixed-base with limitations in the heights achievable and the imposition of checks to horizontal seismic action, through an assigned lateral force design. Between the two it is recommended the second.
The Royal Commission for Technical Standards of construction, concludes his work with the Royal Decree 1080 of 6 September 1912, although with important news, just provide prohibitions and construction requirements.

Meanwhile on the scene also enters Frank Lloyd Wright with the Imperial Hotel in Tokyo.

Imperial Hotel Tokyo

At 11:58 of September 1, 1923 a strong quake of magnitude 7.9, of what will be remembered as the Great Kanto Earthquake, almost completely destroyed the city of Tokyo, killing more than 140,000 people, with a huge number of displaced people .
Shortly after Frank Lloyd Wright a telegram arrived from Tokyo, sent by Kihachiro Baron Okura, owner of the Imperial Hotel:

> ***The hotel is not damaged as a monument to your genius. Thousands of homeless are perfectly secured inside. Congratulations. Okura***

This was followed on September 8, another telegram, this time of his assistant in the hotel's construction :

> ***The first shock was enough to lie down many buildings, and ... the second has easily leveled those that were left standing. The fire went out from every home and ruin those who survived the collapse and fleeing towards the open spaces, were killed by the smoke from the air and on fire, burned by the thousands. All steel buildings have been fatal and that is enough to show how our architects were fools.***
> ***What glory is to see the Imperial straight between the ashes of an entire city.***
> ***Glory to you. Sincerely Arata Endo.***

September 26 FLW writes to his colleague Louis Sullivan:

> ***... The one who saved the Imperial was the principle of flexibility, flexible foundations, flexible joints, flexible piping and wiring, flexible cantilever slabs on supports passing over the exterior walls become balconies and an exaggeration of all the vertical support members , taking the center of gravity as low as possible .***

FLW fascinated by Japanese culture and firmly opposed to the Westernization then starting out, constructs, (reconstructs), Imperial Hotel in a bad ground area: a compact soil layer 2.4 meters thick, on a soft mud layer about 20 meters.
The project is a low-rise building, extended and divided into a box-like bodies are thought of as "floating" on the mud, which FLW then describes how a tray carried by a waiter on the fingers.
The judgment on this is still controversial statement that among the reasons that led in 1968 to the demolition and reconstruction for IH there is also the bad behavior of the backdrop system.

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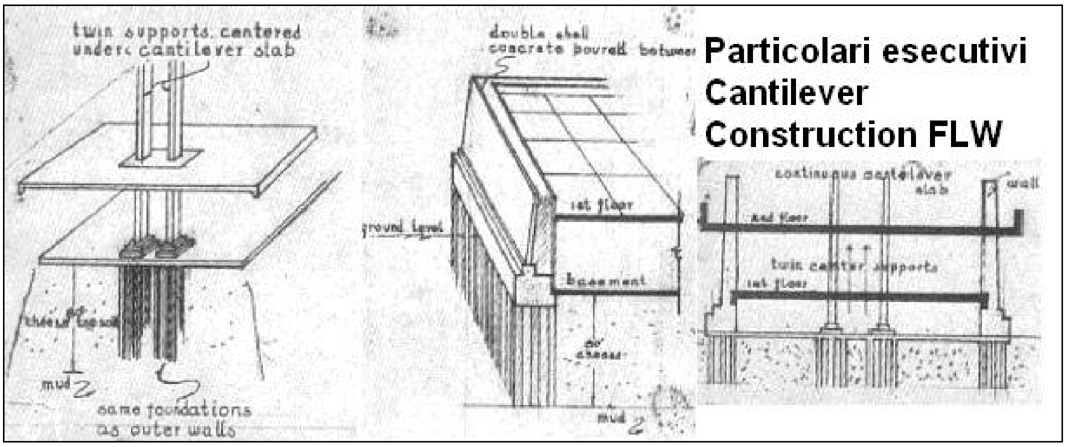
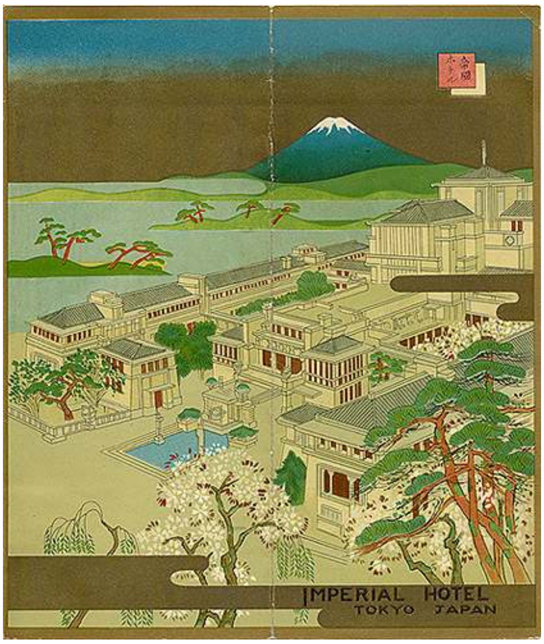
[6] Arturo Danusso, Nel cinquantenario del terremoti di Messina, Il cemento, n.57 1960

After the earthquake, Wright passing the telegram reporters helped to create a legend that the Imperial Hotel unharmed by the earthquake. In fact this was not true because there were damages, albeit slight, so that the insurance company placed it second in the scale up to 5, when there were also large listed buildings 1 and then actually unharmed.
This did not detract from about FLW to have designed and built a beautiful building with many cutting-edge features such as radiant heating, forced ventilation and indirect lighting and many good ideas in the field of seismic risk reduction. The Imperial Hotel remains a rare example of a project where there is a thorough attempt to integrate architecture and engineering in an understandable seismic design strategy.

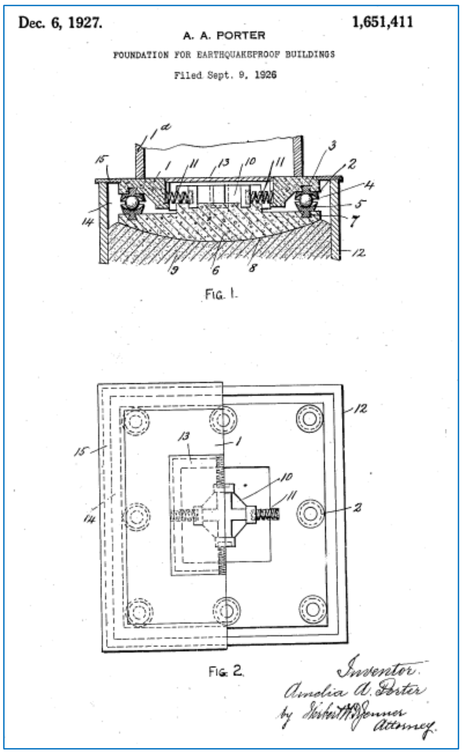


In addition to what has already been described on the division with joints and the low center of gravity of the weights and to the solution for the foundations, to which someone attaches an isolation function to the base while others, on the contrary, they highlight the possible seismic amplification, we want here to recall a fact secondary, but significant. During the work someone did this to Okura Baron that eliminating the pool would save a substantial figure (40,000 yen?). "*The Baron stressed the idea sent for me. He had already made the decision. No my argument took effect. So I said through the interpreter that this was the last resort against the earthquake. In a disaster, the ' aqueduct in the city would no longer worked, and the large amount of wood building and neighboring buildings along the side streets would have risked catching fire, as had already happened in previous earthquakes in Tokyo. no matter. the pool should not be done . no, I told him that it was wrong not to do it, and that this interference freed me from my contract and that I would be back home without further delay. and I left his office. But I did not leave Tokyo and the pool was made and he has done its part in the great drama of the destruction that followed two years later. "*.



In April 1947, FLW asks the General Douglas MacArthur's headquarters in Tokyo, you can help two of his Japanese friends: Arata Endo, who had been his assistant for IH in construction and Aisaku Hayashi hotel manager at the time, sending him money and offering him its hospitality to welcome them to his house.
I feel indebted to them for their immense loyalty.
And, General, so I can praise his humanity towards the vanquished. It is a bright spot in a dark picture. Best regards
Frank Lloyd Wright, Architect
Taliesin: Spring Green, Wisconsin
Frank Lloyd Wright, Architect
Taliesin: Spring Green, Wisconsin

And among the seismic isolation inventors also we find a woman: **Amelia Anne Porter** Lancaster (England) proposes and patented a system in 1926 to "*Foundation for earthquakeproof buildings*". It consists of supports on spring bearings and dampers.



But despite the plethora of proposals, the solutions do not spread because they were difficult to realize in practice, still not complete and functional, also because theoretically the equivalent static method, used to define the seismic loads on the building, did not allow to evaluate its effects.

Soft first Story

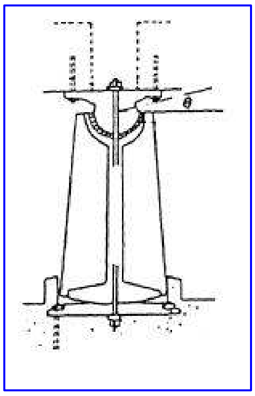
At the beginning of the 30s of last century, it spreads the idea of a possible improvement of seismic performance through greater flexibility of the ground floor (or basement), based on the consideration that in all types of earthquakes the seismic response of buildings with a flexible structural arrangement, it led to the best results of buildings with the rigid structure.
The idea became very popular in the world, because it did not require special measures different from traditional construction methods.
In 1929 R.R. Martel published an article entitled: "The effect of earthquake on buildings with a flexible first story" in which he proposed the so-called "First Soft Floor", which consisted in the introduction of flexible columns on the first floor designed to lengthen the natural period of the structure. Subsequent developments will have with the work of Green (1935) and Jacobsen (1938), introducing the "The Soft first Story Method" with the concept of energy absorption by plasticization.


Hospital Olive View after earhquake 1971

Olive View Hospital in Los Angeles, built by applying this concept, ruined dramatically shortly after the building during the earthquake of San Fernando, 1971 (M 6.6), suffering just the Soft storey mechanism, which was supposed to be a clear protective resource of structure. At the time he lacked the knowledge of the behavior of "nodes" and the detailed design techniques.

The first insulated buildings

Some argue that the first building in the world with an insulation system at the base are even two, both for Fudo Bank to Himeji and Shimonoseki (JP), designed by R.Oka 1928, completed in 1934.


R.Oka isolator 1928

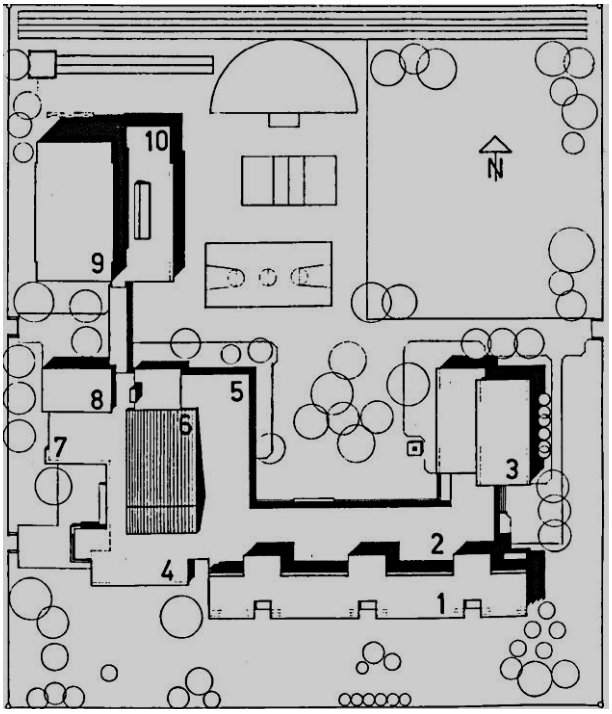
In Volos, Greece, in 1955, Eng. Leon Tsolakis builds a small experimental house with insulation based on devices invented by Pan Keramida.

The first application of seismic isolation in the then USSR is a building constructed in Ashkhabad (Central Asia) in 1959. A building of 4 in a suspended pendulum steel floors, designed by engineer F.D. Zelenkov. Once built manifested large displacements, also of low intensity earthquakes, with the inhabitants of the building that were running in the street, while in the other old buildings nothing had happened.

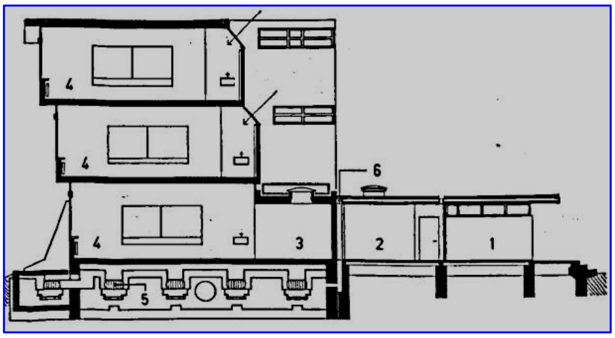
In the following some applications, even with rudimentary technologies, are produced in the Soviet Union around 1960, but it is only in 1969 that we are witnessing the first, pioneering, application of seismic isolation, with the primary school "Johan Heinrich Pestalozzi" in the city of Skopje in Macedonia devastated by a strong

earthquake on July 26, 1963. Donated by the Swiss government; the general project of architect Alfred Roth and that of earthquake-resistant structures by a group of engineers in Zurich: Konrad Staudacher, C.Hubacher and R.Siegenthal, who will describe the principle in Article "Erdbebensicherung im Bauen" (anti-seismic construction) in the Neue Zürcher Zeitung, Technikbeilage, Feb 9, 1970, and referred to as "Swiss Full 3D Base Isolation (FBI-3D)".

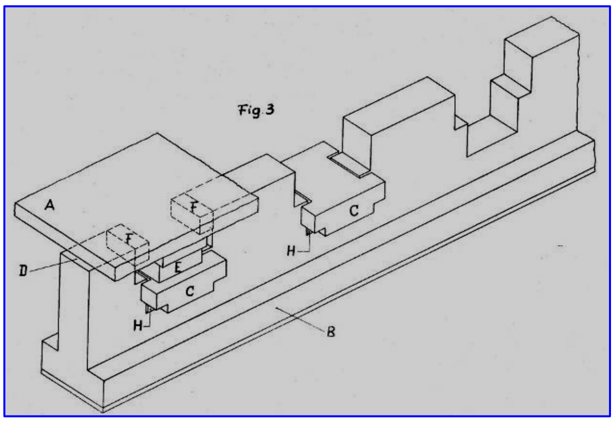
Pestalozzi school in Skopje



The July 26, 1963 Skopje suffered a disastrous earthquake (IX MCS) in which 1,070 people died and more than 3,300 wounded, with more than 80% of homes destroyed or irreparably damaged. Huge damage to infrastructure, schools, hospitals, with damage estimated at $ 800 million.
The earthquake was followed by a clever work of reconstruction on the basis of a master plan developed by Kenzo Tange. The city has grown in size, population and quality of life. Between aid, the Swiss government donated a school building, named after the famous educator "Johann Heinrich Pestalozzi", entrusting the project the Swiss architect Alfred Roth (1903-1998), student of Karl Mozer and of Le Corbusier and with substantial experience in the design of schools. In 1965 the contract was signed, in 1967 started the construction work, completed in 1969 with the official opening of the school.
The campus consists of the building for 18 classrooms (1) 11.0 x 61.5 meters, 10 meters high the only base-isolated, laboratories (3), the auditorium (6) gym (9 , 10) and the caretaker's cottage (8), connected by corridors and passageways (2,4,5,7) in a spacious garden full of green space.



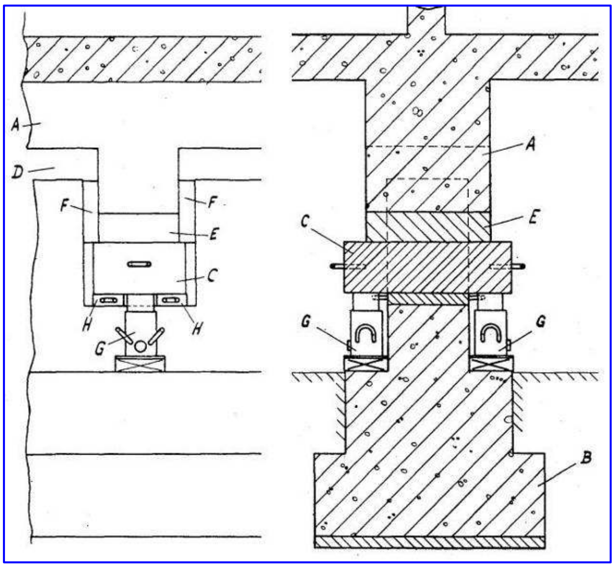
For the building of classrooms Carl Hubacher,Emil Staudacher and Robert Siegenthaler, Swiss engineers were involved, who has long studied the insulation around the base and with the opportunity patented their system called "Abstützung von bauwerken zum schutz derselben beautiful Erschütterungen ihrer Fundamente. " Support Structures for the protection of buildings from the shock to its foundations. Swiss Patent n. 450 675 of 30.04.1968, and after:
Patent USA 3510999 - 12/5/1970
Patent Austria 282287 - 10/07/1970



The building of the Pestalozzi school classrooms has a network of foundations upside beam, on which rubber isolators with low damping 70x70 cm and 35 cm high were laid, produced by Huber-Suhner by Zurich. The system involves a conformation to the steps of the contact between the building (A) and the foundation (B) and in which were placed the elastic bearings (E), compounds from a mixture of natural rubber. Sacrificial elements (F) in the cellular concrete, provide the wind stability and to earthquakes modest. The support beam (C) and the thickness (H), allow the replacement operation of the bearings, through the use of hydraulic jacks (G).

The insulators, compounds from the duplication of 7 cm thick rubber sheets, not armed, had a vertical stiffness, comparable to the horizontal and this entailed a high deformability of the structure also in the vertical direction, so that there was the need to place additional constraints for stabilize the building against wind.

In 2007 all the insulators have been replaced by modern type insulators HDRB (High Damping Rubber Bearing)



In 1972 prof. Aristarchos Ikonomou, University of Patras in Greece, in Athens builds a tall office building with base isolation, through the use of Alexisismon system, he invented and patented.[7]

After the initial period, pioneering, research is directed towards rubber devices and the first insulator, were produced in the 70s in England, from the Malaysian Rubber Producers' Research Association (MRPRA), through a process based on the vulcanization of layers rubber between them isolated from laminations of steel. The first application of this system has in France for the protection of some nuclear power plants, with the combination of rubber and a sliding devices insulators (Electricite de France system).

It's' the cooperation between the MRPRA and the Earthquake Engineering Research Center (EERC)[8] University of California at Berkeley, and between the Department of dynamic of the structures of the CNRS[9] in Marseilles and the John A. Blume Earthquake Engineering Center at Stanford University, California , that research begins to deliver concrete results through shaking table tests, for evaluating performance of devices.[10]

College Jean Guéhenno by Lambesc in Provenza.

Built in 1978-79, in the area hit by the earthquake of 11 June 1909, on a design by architects Ello and Ives Castel, with eng. Gilles Delfosse for anti-seismic structures, the College of Lambesc, has an original and innovative configuration and is able to withstand an earthquake of magnitude 6 and with a reduced according to the cut of 2/3 compared to the same fixed-base structure. A simple architecture consists of 3 cubic buildings of modest height, with seismic joints than ten centimeters between each block, to prevent hammering between the buildings. The foundations rest on a rigid

[7] It seems that the permits were for a fixed-base building, not existing regulations. We thank prof. Panayotis Caridis and Eng. Christos Giarlelis for valuable information about A.S. Ikonomu and isolation in Greece.
[8] today PEER- Pacific Engineering Research Center
[9] Centre National de la Recherche Scientifique (CNRS), the research institute top of the French Republic .
[10] The main researchers are Gilles C. Defosse, C.J. Derham (MRPRA), James Marshall Kelly (University of California Berkeley), R. Ivan Skinner. PEL-DSIR, NZ).

substrate (limestone), they are all linked together and bring 152 pilasters which rest on seismic isolators GAPEC of type, developed by Gilles Delfosse in the laboratory of mechanics and acoustics of the Centre National de la Recherche Scientifique "(CNRS) Marseille, alternating steel and rubber plates.
Four years after the construction, in 1982, a delegation of San Bernardino California came to visit the building for the application of this isolation technique in his city.

Delfosse and the GAPEC isolator

Gilles Charles Delfosse was born June 23, 1929 in the city of Avesnelles, in northern France. Coming from a family with a long tradition in the construction industry, it was only natural that the young Gilles would become a civil engineer. As it happened in 1951, at the prestigious Conservatoire National des Arts et Métiers in Paris. On September 2, 1952 he married Andree Mieze, with whom he had three sons (Patrick-1953, Erick-1955 Christophe-1968). From 1960 to 1962 he moved with his family to Beni-Ilmane (Melouza) in Algeria, where he works as a civil engineer for the colonial government, gaining experience in seismic design, in the reconstruction of rural areas destroyed by the earthquake. After returning to France it is sent by the French government in Skopje in Macedonia, destroyed by the earthquake of 26 July 1963, to contribute to its reconstruction. And 'in this period that takes shape the idea of earthquake protection through insulation at the base.
In June 1969 he graduated in Science from the University of Aix-Marseille with a thesis on the structural dynamics and seismic isolation. Some months later, in February 1970, he was appointed researcher at the Centre National de la Recherche Scientifique (CNRS), the research institute superior of the French Republic, where he created and directed the Department of structural dynamics. His work at the CNRS contributes to the definition of elastomeric isolators and makes it known internationally.
In 1972 it registered a patent for anti-seismic devices for basic insulation under the trade name of GAPEC (Designation of the initials of his entire family names). With this system are protected a large number of structures (buildings and equipment) in France, Martinique, and California. Particularly in France, Delfosse designs seismic isolation of 4 dwelling houses (1977-82), realizes the isolation of the college Guéhenno to Lambes (1978-79), a repository for nuclear waste (1982) and two nuclear power plants at Cruas and Le Pellerin.
In 1979 the State Department of Water Resources, is sponsoring a research program for the protection of electrical devices 230 KV ATB 7, which break in the earthquake of San Bernardino of 1971 has had negative effects, through the use of GAPEC insulators. The results of the tests, certifying that the acceleration on electrical devices is reduced to 1/5.
In 1980 he sets out the four basic criteria of efficiency of a "aseismic Building Isolator System":

1) A low acceleration of the building under a given seismic action
2) A behavior predominantly translational
3) No amplification of vertical motion with respect to the motion of the ground
4) A satisfactory response to large shifts that may occur

He died January 10, 2003.

In 1974 he begins in New Zealand a commissioning program safety of bridges by the earthquake, through the use of insulators, the first is the Motu Bridge.

Somplago Viaduct

But it is with the Friuli earthquake of 1976 that will unlock the reluctance about the use of insulators in bridges. There was in fact building the motorway Udine-Carnia and the only work of art in not suffering harm was the viaduct Somplago (deck girder continuous, long 1240 m, designed by Eng. Renzo Medeot) thanks to a protection seismic based on the insulation, which is one of the world examples on a bridge structure.

Each project must be authorized, lacking legal references. You should expect in 1990 when Italy come out, among the first in the world, the "Instructions for the seismic design of bridges with the use of insulators / sinks devices", while in 1993 will be released the first guidelines for seismic isolation of buildings.

The 80s see the seismic isolation official recognition, with the rapid spread of applications around the world, especially in the US, New Zealand and Japan.

The William Clyton Building Wellington (NZ), 1981, was one of the first buildings to be designed with seismic isolation with lead rubber isolators (LRB).

Foothill Communities Law and Justice

The first building block to the base in the USA was completed in 1985 and is the Foothill Communities Law and Justice Center of the City of Rancho Cucamonga about 100 kilometers east of Los Angeles, 20 km from the fault of San Bernardino. A 5-storey building, with steel structure (126x33,6 mt). Designed to withstand an earthquake of magnitude 8.3, with a maximum displacement in the corners of 38 cm, has 98 elastomeric isolators (HDRB) made on the basis of studies and tests of the EERC[11].

The first building with seismic isolation built in Japan in 1983. From 1983 to 1992 about 67 buildings were isolated at the base were authorized by the specific committee in the absence of a specific code in the BCJ coming out in 1991.

The consecration of the seismic isolation system has with the two strong earthquakes of Northridge California (Mw 6.8- 17/01/1994) and Kobe (Mj7.3- 17/01/1995), in which the non-insulated buildings suffer damage, remaining operational, unlike conventional buildings, severely damaged.

Significantly, the Olive View Hospital, rebuilt after the fall of 1971 with a fixed base structure, while not undergoing major structural damage, is in fact inoperative for damage to finishes and equipment, while the University of Southern California Teaching Hospital, built in 1991 and seismically isolated, remains intact and operational, and also able to receive the patients, while being only 36 km from the epicenter of the Northridge earthquake.

Similarly, with the catastrophic Kobe earthquake, in Sanda City, two large insulated buildings at the base, Matsumura-Gumi Research Laboratory and the West Japan Postal Savings Computer Center, which at the time was the largest building block in the world, remain intact.
In the three years prior to the earthquake in Kobe, they had been allowed 15 blocks buildings, within three years it will be authorized 450.

[11] Gli stessi dispositivi che saranno usati alla SIP di Ancona.

The disastrous earthquake by Hanshin-Awaji Kobe 17.01.1995 (JP)

The two isolated buildings of Sanda City

Computer center of the Ministry of Post and Telecommunications
6 floor decking area of 46,823 square meters, then the largest building block in the world
Isolator: 54 LRB d120h24 +46Low Damping natural rubber d100 h20
20Low Damping natural rubber d 80 h16+44 steel damper

Matsumura Laboratory Corporation
3 floor decking area of 480 square meters insulators: 4HDRB d70h13,5 + 4HDRB d60h13,7

The original experience in the USSR

In 2012 more than 600 buildings and other structures built in the Russian Federation countries, with base isolation.
Only since 1990 in the former USSR intervention with rubber isolators they are developed. Until then studied original systems have been used and tested at the Central Research Institute for Building Structure, Earthquake Engineering Department (TsNIISK) in Moscow.
Since the '70s was implemented a program to basic insulation for residential buildings and services. Another exception is that of nuclear power plants for which rests with sliding supports and pneumatic systems have been employed.
Seismic isolation is achieved by using two or more elements: a flexible element and a damper. The flexible elements, placed at the ground floor, can be of slender oscillating supports or columns, while the dampers are elements in mild steel or reinforced concrete panels sacrificial or slip couplings.
Basically there are two original systems developed and manufactured at that time: buildings with flexible basis and elements dissipative sacrificial (DRE) and buildings with pivot bearings (kinematic) (KRS).

Buildings with DRE
In 1973-74 a whole new city, in the north of Lake Baikal, between Mongolia and Siberia, was built with a particular type of seismic protection. This type of building is characterized by a system called "Disengaging Reserve Elements" (DRE). The DRE are installed on the ground floor of the

building, which is a reinforced concrete frame structure, while the upper part, usually of 9 floors, is in load-bearing walls, both to large panels of masonry. The DRE is a "rigid structure", generally a concrete panel, connected to the reinforced concrete frame by means of special sacrificial elements (fuses). They can be of steel plates together by means of rivets or bolts, d 'steel bars, cubes or prisms of concrete, etc. For low values of the seismic action the DRE and reinforced concrete framed structure work together, at this stage, the defusing element transfers side loads to the frame. For stronger actions activates the DRE whose sole function is the change (self-adjusting) the rigidity and the vibration periods during an earthquake, avoiding the resonance. The DRE are sacrificial elements and therefore to be replaced after the earthquake.
The first building protected by this technique has been to a bank and built in 1972 in Ukraine in Sevastopol.

Buildings with KRS
This system, which unlike the previous one is a true base isolation, involves the construction on the ground floor of the building of oscillating elements, placed between the bottom floor and the first level. The concrete elements in the shape of tetrahedral truncated pyramid, have the lower base and the upper spherical hinged to the superstructure. In static conditions the weight keeps the device in the stable equilibrium state and determines the lateral stiffness that depends on the weight of the superstructure from the height of the element and the radius of curvature of the pin. Sometimes metal pillars are added to increase the damping of the system.
Buildings of this type were built in Sevastopol, while in Alma-Ata the oscillating support has taken the form of an inverted mushroom.
Four buildings constructed with this technique in the city of South Kurilsk, Kuril Islands in the Pacific Ocean, suffered the strongest earthquake of 04.10.1994, showing a better behavior of similar conventional buildings.

KRS Isolators

The example of Armenia

Armenia (3,000,000 inhab.) was upset December 7, 1988 from Spitak earthquake (Ms 6.8) with 25,000 dead 50,000 wounded 500,000 displaced.

In 1994 for a series of favorable circumstances, in this small country is excellent engineering and retrofitting initiatives are developed with base isolation:

1- The presence of a group of designers with the knowledge and necessary technical
2- International institutions willing to invest
3- Four factories of insulators

Today the number of isolated buildings at the base per capita is second only to that of Japan.

Of particular interest in the technique used for new buildings with the use of groups of small insulators instead of a larger one, this ease the assembly and replacement of devices and allows a better calibration of the project especially against the rotation of the building .

The seismic retrofitting with the use of insulators

Always in the 90 seismic isolation it is beginning to be used in even the upgrading operations, having the advantage, compared to traditional techniques, to not have to touch the existing structure. It paves the way for the adaptation of the **Salt Lake City** and County Building, a stone building with 5 floors and a tower, built in 1893. The earthquake adaptation studies can begin in 1973 and materialize in 1983 with the analysis of various solutions among which the best is that of isolation at the base, with the use of New Zealand's rubber isolators (208 and 239 lead rubber natural rubber bearing). The works, which include the creation of a new seam between the foundation and walls, for positioning the bead end in 1989. They are still the United States to lead the way, after the Loma Prieta earthquake of 1989, with **City Hall in San Francisco and Oakland** who had suffered considerable damage. Both could not be demolished because the former was a national monument, and the second, at the time of its construction (1914), was the tallest building on the West Coast. For adaptation they were employed 111 reinforced rubber isolators, of which 36 with lead inserts. The insertion of the devices took place with the cutting of the steel columns to the bottom floor, with the aid of hydraulic jacks. The building can now move 50 cm. The total cost was $ 85 million. Similar operation after the earthquake, for the adaptation of the San Francisco City Hall, built in 1915, and one of the most important and significant examples of classical architecture in the United States. The adaptation of the City Hall in Los Angeles, completed in 2001, is instead following the Northridge earthquake. Built in 1926, the top 32 floors, was the first building to exceed the limit of 150 ft in height, without a particular seismic design. Lesions in the lining walls (the main structure is made of steel) appeared since the earthquake in San Fernando (1971). The insulation project involved 416 insulators HDR and 90 sliding supports, in addition to 52 viscous dampers to the floor foundation and the 12th to 26th floor.

With a jump to this we simply highlight the Armenian experience for the application of the retrofitting of historical buildings with interventions on ancient buildings and important, as this school in **Vanadzor**, made in 2002, without having to leave the building.

The path of history: first doubt, then the reason and now the actuality

doubt

... It therefore seems that the best directive to the solution of the problem is represented by the following question: Make a minimum, consistent practices hill needs a home, the amount of energy that is transmitted by the telluric emotion to the building. To many it seemed that this statement contained not the beginning but the end of the desired solution. They said: we reform completely the way of building support on the ground: instead of rooting it on a firm foundation, liberiamolo so that it rests above a kind of mobile carriage in all directions with the least possible friction. The earthquake drag force will tend to fade and the building will remain unperturbed, while the furious shake under his feet. The reasoning is quick, elegant and is flawless. But, to translate it in place, the applicants have had to resort to a series of mechanical devices such as rollers, balls, springs and elastic suspensions, devices that distort the house since convert the foundations, which should possess a secular stability, in a metal system that it needs to be taken care of, supervised,

lubricated for fifty to one hundred years, from generation to generation, and that eventually, shaken by an earthquake, with supreme ingratitude work poorly or not work at all. Imagine, for example, one of the steel balls which for a century has been firm to bear the weight of the building and think only friction breakaway that it should win to get moving and free your home from the effects of the shock! I do not think here the case to proceed to a severe criticism of these mechanical systems. Those who visited the exhibition of the works presented at the recent Milan contest where such systems appeared in large numbers with all its kit models and drawings, has certainly brought the impression of their failure for the purposes of the practice.

Arturo Danusso, La statica delle costruzioni antisismiche
Atti della Società degli Ingegneri e degli Architetti in Torino 1909.

reason

... Rather than limit funding to stress that the calculation indicates that should arise in a given structure, you may be wondering how you could design a structure that would reduce the mechanical energy flow that the ground, shaken by the earthquake, tends to send ... it would be possible to study the introduction of mechanisms to rapidly dissipate mechanical energy or to prevent its transmission.

You can also design rubber supports or other elastic material which have precisely the task of leaving virtually immobile the building, while below it the foundations for vibrating effect of the earthquake ... it comes to obtaining a large system deformability, in this case localized the media, and therefore proportionately much inert and with its own very low frequency, as otherwise it would not be possible with normal structural types.

Sergio Musmeci,
Introduzione alle costruzioni antisismiche,* GEAP *1978

The actuality

The chronicle takes us this brief history in the use of seismic isolators:

1969 in Skopje (Yugoslavia), the Pestalozzi School;
1972: Athens (Greece), in an office building;
1973: in New Zealand, on Motu Bridge;
1974-1976: A23 Udine-Carnia (Italy) in Somplago viaduct;
1978-79: the College Jean Guéhenno in Lambesc in Provence (France)
1978-1981: Wellington (New Zealand), in William Clayton Building (LRB)
1978-1984: a Kroeberg (South Africa), in nuclear power plants EDF;
1981 in Naples (Italy), at the Command of the Fire Brigade
1991: first application pendulum isolators (FPS) for retrofitting "Marina Apartment", San Francisco CA

In Italy, and perhaps in Europe, the first isolated structure was the operational center of the Fire Department of Naples, built in 1981 to a design by Prof. Ing. Federico M. Mazzolani. The building has a suspended structure in steel, with load-bearing reinforced concrete cores. Originally it designed for vertical loads only, after Campano Lucano earthquake in 1980, was isolated during construction, with elastomeric isolators combined with elastoplastic heat sinks of energy, arranged at the top of the towers of reinforced concrete, which support the lattice structure of suspension 'building.

In the world today, there are more than 10,000 buildings equipped with insulators at the base, located in over 30 countries.
Japan after the earthquake in Hyogo-ken Nanbu / Kobe (1995) has strongly encouraged the use of isolation simico and has the leadership in the world, with over 50% of applications.
The People's Republic, Giant recently on the scene and already in second place.
The Russian Federation, in which the insulation is spread by time with the original indigenous systems and now is opening the use of rubber insulation systems, Western-style.
The United States of America, where the spread continues normally, without the surge in Japan, also due to a very punitive legislation.
Italy, that after the brilliant start with the isolation of bridges and viaducts, since 2003 has governed the use for the buildings.
Following New Zealand, highly specialized in the production of devices, Taiwan and Armenia where recent earthquakes have encouraged the use. Mexico, where the first experience is of 1974. The France, concentrated on nuclear power plants.
Without forgetting the achievements in Turkey, Greece, Portugal, Venezuela and Cyprus and, more recently, in Argentina, Israel, India, Romania and Iran, South Korea, Canada, Chile, Indonesia and Macedonia.

The seismic insulation use is spreading especially for the protection of buildings and strategic value: hospitals, operating rooms for emergency, computing centers, museums, and in general in all those buildings whose functionality is essential in the case earthquake .... but this is no longer the story, but chronicle.

References

Base Isolation: Origins and Development
James M. Kelly
EERC News, Vol. 12, No. 1, January 1991.

Earthquake that have initiated the development of earthquake engineering
Robert Reitherman
Bulletin of the New Zealand society for earthquake engineering, Vol. 39, No. 3, September 2006

The implementation of base isolation in the United States
James M. Kelly
Eartquake Engineering, 10 World Conference
Rotterdam 1994

Historical Aspects of Seismic Base Isolation Application
Ahmad Naderzadeh
Iranian Society of Structural Engineers

Design of Seismic Isolated Structures, From Theory to Practice,
F. Naeim and J.M. Kelly,
John Wiley and Sons, 1999

State of the art report. Base isolation and passive seismic respons control.
Masanori Izumi
9 WCEE 1988 Tokio

Up-to-date earthquake protection
Vladimir Smirnov
Высотные здания/Tall buildings, agosto/settembre 2009

Earthquake Engineering. From Engineering Seismology to Performance-Based Engineering,
Yousef Bozorgnia Vitelmo V. Bertero
CRC Press 2004

Dagli "strati di carbone e lana" ai moderni dispositivi antisismici
Paolo Clemente
Attività in campo sismico.
Recenti studi e sviluppi futuri
Casaccia, 20 dicembre 2010

I sistemi antisismici in Sicilia, in Italia e nel mondo: dall'isolamento sismico della scuola Johan Heinrich Pestalozzi a Skopje negli anni '60 a quello della nuova Francesco Jovine, 'la scuola più sicura d'Italia', a San Giuliano di Puglia nel 2008"
Alessandro Martelli
Seminario "Centenario del Terremoto e del Maremoto di Messina e Reggio Calabria: 1908-2008, un Secolo di Ingegneria Sismica",
Messina il 30 ed il 31 gennaio 2009.

Soft Story Risk Reduction: Lessons from the Berkeley Data
A Special Projects and Initiatives report to Earthquake Engineering Research Institute
David Bonowitz, Sharyl Rabinovici,
EERI January 2013

Recent developments in seismic isolation and energy dissipation in Russia
J.M.Eisenberg,V.I.Smirnov, A.A.Bubis
14 world conference on Earthquake Engineering
October 12 – 17, 2008 Beijing, China

Analysis of 3-D vibrations of the Base Isolated School Building "Pestalozzi" by analytical and experimental approach
Garevski A Mihail.
Proceedings of Ninth World Conference on Earthquake Engineering, 12 (2000)

Guia de diseño sismico de aisladores elastopmerico y de Friccio para la Republica de Nicaragua
Tesi di Roger Ivan Meza Blandon e Edgard Ezequiel Sanchez Garcia
Universida Nacional de Ingenieria
Giugno 2010

The GAPEC system: a new highly effective asesmic system
Delfosse Gilles C.
6WCEE New Delhi, India 1977

Full earthquake protection through base isolation system
Delfosse Gilles C.
7WCEE Instanbul, Turkey 1980

The 1995 Kobe (Hyogo-ken Nanbu) Earthquake as a Trigger for Implementing New Seismic Design Technologies in Japan
Peter W. Clark. Ian D. Aiken, Masayoshi Nakashima, Mitsuo Miyazaki, Mitsumasa Midorikawa
Lessons Learned Over Time, Learning From Earthquakes, Volume III
Earthquake Engineering Research Institute, 1999

The Seismic Retrofit of the City and County Building in Salt Lake City: A Case Study of the Application of Base Isolation to a Historic Building.
Prudon, Theodore H. M.
In: Old cultures in new worlds. 8th ICOMOS , 1987

Seismic retrofit and instrumentation of los Angeles City Hall

Nabih Youssef and Owen Hata
SMIP05 Seminar Proceedings

The seismic retrofit of the Oaklan City Hall
Mason Walters,
SMIP03 Seminar Proceedings

Alexisismon seismic isolation levels for translational and rotational seismic input

A.S. Ikonomou
8 WCEE 1984 Los Angeles

Seismic isolation of buildings and historical monuments. Recent developments in Russia.
V. Smirnov, J Eisembreg, A.Vasil'eva
13 WCEE Vancouver Canada, 2004

Buildings protected with "disengaging reserve elements"
Report Date 05-06-2002
Jacob Eisenberg, Svetlana Uranova, Ulugbek T. Begaliev
World Housing Encyclopedia

Armenia is the one of the world leaders in development and application of base isolation technologies
Mikayel Melkumyan
American University of Armenia (AUA), Engineering Research Center (ERC), Yerevan, Armenia.

Isolatori Sismici per edifici esistenti e di nuova costruzione
Dora Foti, Michele Mongelli
Flaccovio editore 2011

Behavior of base-isolated buildings in the 1995 great Hanshin earthquake and overview of recent activities of seismic isolation in Japan
Takafumi Fujita
Proceedings of the international Post SMiRT Conference seminar on Seismic isolation, passive energy dissipation and control of vibrations of struttures
Santiago de Chile 1995

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Frank Lloyd Wright's Imperial Hotel A seismic re-evalutation
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